DRAFT

SINGLE EVENT EFFECTS SPECIFICATION

1. Definitions and terms:

- *Single Event Upset (SEU)* - a change of state or transient induced by an energetic particle such as a cosmic ray or proton in a device. This may occur in digital, analog, and optical components or may have effects in surrounding interface circuitry (a subset known as Single Event Transients (SETs)). These are "soft" errors in that a reset or rewriting of the device causes normal device behavior thereafter.
- *Single Hard Error (SHE)* - an SEU which causes a permanent change to the operation of a device. An example is a stuck bit in a memory device.
- *Single Event Latchup (SEL)* - a condition which causes loss of device functionality due to a single event induced high current state. An SEL may or may not cause permanent device damage, but requires power strobing of the device to resume normal device operations.
- *Single Event Burnout (SEB)* - a condition which can cause device destructiondue to a high current state in a power transistor.
- *Single Event Gate Rupture (SEGR)* - a single ion induced condition in power MOSFETs which may result in the formation of a conducting path in the gate oxide.
- *Single Event Effect (SEE)* - any measurable effect to a circuit due to an ion strike. This includes (but is not limited to) SEUs, SHEs, SELs, SEBs, SEGRs, and Single Event Dielectric Rupture (SEDR).
- *Multiple Bit Upset (MBU)* - an event induced by a single energetic particle such as a cosmic ray or proton that causes multiple upsets or transients during its path through a device or system.
- *Linear Energy Transfer (LET)* - a measure of the energy deposited per unit length as a energetic particle travels through a material. The common LET unit is MeV*cm2/mg of material (Si for MOS devices, etc...).
- *Threshold LET (LETth)* - the minimum LET to cause an effect at a particle fluence of 1E7 ions/cm2. Typically, a particle fluence of 1E5 ions/cm2 is used for SEB and SEGR testing.

2. Component SEU Specification

2.1. No SEE may cause permanent damage to a system or subsystem.

2.2. Electronic components shall be designed to be immune to SEE induced performance anomalies, or outages which require ground intervention to correct. Electronic component reliability shall be met in the SEU environment.

2.3. If a device is not immune to SEUs, analysis for SEU rates and effects must take place based on LETth of the candidate devices as follows:

Device Threshold	Environment to be Assessed
LETth < 10 MeV*cm2/mg	Cosmic Ray, Trapped Protons, Solar Flare
LETth = 10-100 MeV*cm2/mg	Cosmic Ray
LETth > 100 MeV*cm2/mg	No analysis required

2.4. The cosmic ray induced LET spectrum which shall be used for analysis is given in Figure TBD.

2.5. The trapped proton environment to be used for analysis is given in Figures TBD. Both nominal and peak particle flux rates must be analyzed.

2.6. The solar flare environment to be used for analysis is given in Figure TBD.

2.7. For any device that is not immune to SEL or other potentially destructive conditions, protective circuitry must be added to eliminate the possibility of damage and verified by analysis or test.

2.8. For SEU, the *criticality* of a device in it's specific application must be defined into one of three categories: error-critical, error-functional, or error-vulnerable. Please refer to the Single Event Effect Criticality Analysis (SEECA), http://radhome.gsfc.nasa.gov/radhome/papers/seecai.htm, document for details. A SEECA analysis should be performed at the system level.

2.9. The improper operation caused by an SEU shall be reduced to acceptable levels. Systems engineering analysis of circuit design, operating modes, duty cycle, device criticality, etc... shall be used to determine acceptable levels for that device. Means of gaining acceptable levels include part selection, error detection and correction schemes, redundancy and voting methods, error tolerant coding, or acceptance of errors in non-critical areas.

2.10. A design's resistance to SEE for the specified radiation environment must be demonstrated.

3. SEU Guidelines

Wherever practical, procure SEE immune devices. SEE immune is defined as a device having an LETth > 100 MeV*cm2/mg.

If device test data does not exist, ground testing is required. For commercial components, testing is recommended on the flight procurement lot.